Evaluation of Biomass-to-Ethanol Fuel Potential in California
Annotated Outline
6/4/1999

I. EXECUTIVE SUMMARY

This will be a stand-alone section prepared concurrently with the full report that will include purpose of report, summaries of the technical chapters, major findings, conclusions and recommendations on what steps, if any would be appropriate to foster a biomass/ethanol industry in the state should ethanol be found to be an acceptable substitute for MTBE.

The section will include a discussion of the issues that may impact the potential of a California biomass-to-ethanol industry and potential benefits. Issues that may hinder or limit the industry's growth include: high capital requirements, uncertain motor fuel regulations, lack of experience with cellulosic ethanol production, high production costs, uncertain demand, lack of well developed infrastructure and others.

Major findings will include gross waste biomass resources, potential biomass resources from energy crops and amounts likely to be economically viable. The report will also discuss production economics and the likely potential for technical improvements for biomass conversion technologies.

II. INTRODUCTION

This section will introduce the subject by reciting *the relevant section (Item # 11) of the Governor's Executive Order of March 25, 1999 and relating this to other completed and ongoing work involving California's phase-out of MTBE. Ethanol's potential role as an MTBE replacement will be noted. The scope of the study's evaluation of potential ethanol production in California will be set forth, including a brief description of the types of biomass resources to be considered, distinguishing between waste-based sources and other sources (i.e. energy crops). The concept of multi-purpose projects to produce ethanol and electricity and simultaneously address waste disposal, forest management and other environmental problems will be introduced.*

III. BACKGROUND AND "SETTING THE STAGE"

This section (actual title to be determined) will develop a perspective on ethanol as a transportation energy option and establish a context for the evaluation of prospects for a California ethanol fuel industry presented in the remaining sections.

History and Status of Ethanol as a Fuel
Major world examples of production and use of ethanol fuel to date will be briefly reviewed, highlighting the U.S. situation.

California Experience with Ethanol Production
Past cases of ethanol production in California will be described, including various demonstration projects and feasibility studies, some of which have been sponsored by state government (e.g., SB 620). An existing commercial waste biomass-to-ethanol venture will be examined.

Proposed Ethanol Projects in California
The features and status of several biomass-to-ethanol projects currently being planned or proposed in California will be summarized. Co-location of these projects with biomass electric generation plants and other multi-purpose features will be described.

Fuel Ethanol Markets
The application of ethanol in motor fuel markets will be examined in more detail, focusing on California application as a gasoline blending (oxygenate) component. Use of ethanol, as a neat fuel will also be described. Historical trends in the use of ethanol fuel in the U.S. and California will be shown, noting factors that have affected these trends. Prospects for growth in ethanol fuel markets will be generally outlined for different potential scenarios.

State and Federal Air Quality Issues
California Air Resources Board and U.S. EPA regulations affecting the use of ethanol as a gasoline blending component will be briefly reviewed, including potential changes to these regulations that could improve or diminish the attractiveness of this market for ethanol in the state. These regulations will determine the allowable percentages of ethanol blended in California gasoline.

Ethanol as Part of California's Response to the MTBE Issue
The history of the MTBE issue and the phase-out initiative will be briefly recounted, focusing on the identification of ethanol as a likely substitute. Results of the CEC study "Supply and Cost of Alternatives to MTBE in Gasoline" related to ethanol will be summarized, and other ongoing investigations of ethanol as a California gasoline

component will be noted. The range of ethanol volumes potentially blended in California gasoline will be considered.

Ethanol Supply Possibilities from In-State and Out-of-State Sources

Possible sources of ethanol supply from various sources within and outside the state will be generally inventoried, describing the different opportunity and constraint factors associated with these different sources. Both traditional supply sources and new sources that a growing market for ethanol might attract (such as methanol conversion to ethanol) will be considered.

Government Tax Treatment of Ethanol Fuel

Past and present actions by government affecting the production and use of ethanol will be reviewed, including the federal ethanol tax subsidy and import tax, and the previous California tax subsidy.

IV. WASTE BIOMASS RESOURCES IN CALIFORNIA

This section will define and describe biomass; waste biomass and residues identified as candidates for ethanol production and provide quantitative estimates of the resource potential in California for the types of materials included in the waste and residual biomass categories. Economic, environmental and other factors, including competing markets and disposal options, affecting the viability of ethanol production from these sources will be examined.

Definitions and Descriptions

The different categories of biomass resources and characteristics that affect their potential as ethanol feedstocks will be distinguished. Major categories of waste and residual biomass will be reviewed, including materials from forestry, agriculture, and urban sources.

Gross Resources and Distribution

Available resource potential for the above materials showing distribution by regions of California will be presented.

Resource Impacts and Benefits

Environmental, economic and resource opportunities and constraints to collecting, transporting and processing the above types of biomass materials will be described. Issues affecting the use of these materials for ethanol production will be identified.

Disposal Options and Competing Markets

Various options to use of the above materials for ethanol production will be reviewed. These will include other energy and commodity markets, and disposal options such as burning, landfill disposal, tilling, etc.

Out-of-State Resources
Potential supply availability of waste biomass resources from neighboring states will be briefly considered.

Supply Curves
Methodology will be applied to examine the relationship between cost and availability of waste biomass resources considered major candidates for ethanol production.

V. BIOMASS CROP RESOURCE POTENTIAL IN CALIFORNIA

This section will examine the potential for the harvesting of cultivated and naturally occurring crops that are candidate feedstocks for ethanol production. This includes dedicated energy crops (e.g., switchgrass, poplar trees) and multi-use crops (e.g., corn, sugar beets). Aquaculture crops will also be briefly discussed. Near-term and long-term potential for energy crop development, considering economic, environmental and resource factors affecting the viability of ethanol production from such sources, will be considered.

Types of Resources
The various types of energy crops identified as potential feedstocks for ethanol production will be listed and described, and their likely applicability to California indicated.

Energy Crop Potential
Near-term and long-term outlooks for exploiting energy crop resource potential in California will be estimated, considering regional applicability. Co-product options will also be considered.

Resource Impacts
Resource requirements (and potential constraints) for energy crop development will be examined. This includes land availability, irrigation water requirements, energy inputs, etc.

Obstacles to Energy Crop Production
Potential economic, environmental and socio-political issues (e.g. energy vs. food crops) to be faced by an energy crop industry in California will be discussed.

Out of State Crop Potential
Possible use of energy crops from other states to produce ethanol in or for California will be briefly examined.

Supply Curves
Cost versus availability of potential energy crops for ethanol production will be analyzed.

VI. BIOMASS-TO-ETHANOL CONVERSION OPTIONS

This section will review the various technologies being considered for producing ethanol from biomass in California. Process descriptions, production efficiencies and status of development and application will be presented for both established and emerging technologies capable of producing ethanol from the types of feedstocks identified in previous sections. Options for combined production of electricity and other co-products will be included.

Leading Cellulosic Conversion Technology Candidates
Cellulosic conversion technologies being considered in the near term will be reviewed. These include dilute acid, concentrated acid and enzymatic hydrolysis. Fermentation options will also be highlighted.

Other Cellulosic Conversion Technology Options
Technologies such as direct microbial conversion, lime-based hydrolysis, gasification-fermentation and others will be briefly covered here.

Grain- or Sugar-Based Processes
The current widely used process for most world ethanol production will be described for completeness.

Cogeneration/Co-Production of Other Products
The new approach involving a "biorefinery" designed to produce ethanol, electricity and other chemical products will be detailed.

Technology Improvements and Their Effect on Production Economics
Literature will be reviewed on technology improvements and what a mature biomass-derived ethanol industry might look like. Cost reductions for ethanol production will be examined from these anticipated advancements.

VII. BIOMASS TO ETHANOL PRODUCTION POTENTIAL IN CALIFORNIA

This section will combine the study results for biomass resource potential and ethanol production processes presented in previous sections to develop estimates of ethanol production potential in California. Ethanol production estimates will be developed based

on various economic parameters (ethanol at different price scenarios, as well as various production cost scenarios). This section will also include initial analyses of production considerations for waste biomass and energy crops, such as geographic aspects, infrastructure and distribution requirements, and other identifiable factors affecting the viability of this industry in the state.

Gross Estimates of Ethanol Potential
The magnitude of ethanol supplies producible from the types of biomass residues and energy crop feedstocks described and quantified in previous sections will be estimated.

Geographic Distribution and Implications
Geographic areas of the state most likely to be candidates for ethanol production facilities in regard to waste biomass collection and transport will be identified and the local/regional implications for these potential host areas described.

Production Facility Features and Requirements
Operating features and requirements for nominal biomass-to-ethanol production facilities of the types likely to be located in California will be described**.**

Infrastructure and Distribution Systems
Support requirements for a biomass-to-ethanol production industry, for feedstock collection and transportation, facility operation, and product distribution will be characterized.

Constraints and Challenges
Technical, economic and institutional factors likely to affect the viability of individual biomass-to-ethanol projects and an expanding overall industry in the state will be enumerated. Ethanol product quality requirements for motor fuel application will be briefly addressed.

VIII. ECONOMIC EVALUATION

This section will examine the economics of biomass-to-ethanol production in California and assess the potential cost of new ethanol production in the state compared with conventional ethanol supply sources. A number of different production scenarios incorporating different feedstock and production process options will be analyzed and other economic implications of this new industry, such as employment, will be appraised.

Conventional Ethanol Production Facilities
Costs associated with conventional corn-based ethanol plants currently supplying most ethanol used, as fuel in the U.S. will be estimated to form a comparative benchmark. The newest of these plants use the latest wet milling processes integrated with electric power generation and food and animal feed products. Feedstock prices as well as the markets for

co-products affect resulting ethanol prices.

Short and Intermediate Term California Ethanol Production Costs
Costs of ethanol will be estimated for various scenarios involving different feedstocks, locations, and plant types (including stand-alone and integrated plants), plant operating assumptions, time frames, and other factors.

As discussed in Section VI, several cellulose conversion options have been analyzed for feedstocks in California. These analyses have shown similar costs of production among conversion technologies with the same level of technology maturity and feedstock costs. An estimate of production costs will be performed for different feedstocks that are available in California using a dilute acid and enzymatic conversion process, which has been shown to have a broad range of technical feasibility. Some of the factors affecting ethanol production costs that will be evaluated include:

- Stand alone and integrated plants
- Feedstock cost
- Plant size
- Plant economic factors
- Time horizon
- Ethanol production yield

Long Term California Ethanol Production Costs
Over the long term, ethanol production in California would evolve towards improvements in processing technology and additional feedstocks. As experience is gained with cellulose based production, increased ethanol yields, reduced enzyme costs, and the opportunity for production of value added co-products would reduce the cost of ethanol production. Additional feedstocks such as energy crops and additional urban waste materials may be economic. The cost of long-term ethanol production will be assessed for various scenarios that take into account improvements in production technology and increased availability of feedstocks.

Ethanol Supply/Cost Outlook from Out-of-State Sources
Cost of ethanol expected to be supplied to California in the near term from conventional out-of-state sources will be estimated. The potential for expanded production from these sources to supply increased/sustained California demand for ethanol in the longer term will also be examined to provide a comparison with cost estimates for potential in-state ethanol production.

Economic Opportunity and Risk Factors Associated with a California Ethanol Industry
The economic benefits as well as the risks associated with development of a California biomass-to-ethanol industry will be summarized.

IX. & X. STEPS TO FOSTER A WASTE BIOMASS AND/OR ENERGY CROP ETHANOL INDUSTRY IN CALIFORNIA

These sections (or a single combined section – to be determined) will set forth potential actions by California government and other entities that would aid the development of a viable biomass-to ethanol industry in California employing waste residues (Section IX) and/or energy crops (Section X) should ethanol be found to be an acceptable substitute for MTBE. Steps will be considered for improving the attractiveness of waste conversion to ethanol. In both feedstock cases, the problems and opportunities affecting the creation of a California ethanol industry will be reviewed and recommendations provided as to the appropriateness of addressing these issues through state policy initiatives versus private industry activities alone.

Issues That Could Affect Development of a California Biomass Ethanol Industry

Near-term and long-term issues that must be resolved to facilitate large-scale commercialization of ethanol production and distribution in California will be identified. Some of the issues and factors affecting development that will be discussed include:

- Risks of using new technologies
- Financing challenges
- Local permitting and siting requirements
- High capital and operation costs
- Uncertain motor fuel specifications and regulations
- Infrastructure, distribution and storage capabilities/limitations
- Externalities not captured in price of fuel
- Tax base impacts
- Uncertain fuel demand
- Uncertain biomass supply
- Employment opportunities (i.e., sustainable rural employment)
- Air quality impacts
- Greenhouse gas emission benefits
- Landfill diversion and diversion alternatives
- Wildfire reduction
- Forest health/productivity
- Value added co-product/co-generation opportunities
- Fuel diversity/transportation energy mix
- Renewable fuel

State Ethanol and Biomass Energy Policy

Consideration will be given to the pros and cons of a possible state energy policy direction regarding ethanol production from biomass wastes and residues and/or energy crops.

Coordination of Government and Private Sector Actions
The relationship and importance of the roles of various government agencies and private sector entities will be examined. Potential actions by government will be identified, including the following areas:

- Activities to reduce market uncertainty and investment risk and ensure the necessary investments
- Public incentives/mechanisms, both financial and non-financial designed to address specific problems or constraints
- Regulatory changes
- Research, development and demonstration activities
- Educational activities on the costs and benefits of ethanol production and use
- Possible legislative remedies
- Other possible actions

Recommendations
Recommendations for government and industry drawn from the possibilities identified above will be provided, with primary consideration of what role state government should play.

XI. CONCLUSIONS

This section will present the major conclusions developed from the evaluation of the potential for a California waste-based or other biomass ethanol industry. The major trends and opportunities revealed by the study regarding ethanol production and use as a fuel will be presented, and a possible course of action recommended for California State Government will be reiterated.

REFERENCES

*A detailed list of references used to develop the evaluation will be presented for corroboration and further investigation of the subject matter***.**

APPENDICES

*Several technical appendices will be prepared to provide expanded levels of detail and supporting data on some of the above subject areas, potentially including***:**

- Supporting technical data and details on biomass resources
- Details on biomass-to-ethanol conversion technologies, including schematic diagrams, biomass feedstock preference or compatibility, estimated costs, etc.

- Details on economic evaluations and scenario analyses
- List of stakeholders, industry and government participants